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Experiments with Wet Bulb Thermometers.

In the *Meteorological Magazine* for December, 1928, p. 253, some account was given of experiments with wet bulb thermometers at Kew Observatory. Further experiments were made during the spring and summer of 1929. The principal results of these experiments are:—

(1) In the Stevenson screen wet-bulb thermometers give consistent readings when the water is either—

(*a*) Distilled water sucked up from a bottle at a lower level.

(*b*) Distilled water supplied from a reservoir at such a height that the water drips slowly.

(*c*) Tap water* supplied in this way.

(2) If tap water is sucked up from a bottle at a lower level than the wet bulb then the readings are at first consistent with those obtained with the arrangements mentioned in the preceding paragraph. After about four days the wet bulb supplied with tap water becomes less efficient and the readings of this thermometer are higher than those of the other thermometers; the excess is likely to be 0·5°C. at the end of a week and may be as great as 3°C. at the end of three weeks of hot weather.

(3) Vapour pressures determined for the free air outside a Stevenson screen by the Assmann psychrometer and for the inside of the screen by the ordinary dry and wet bulb generally agree within 0·5 mb. (the readings being reduced in each case

*Actually boiled tap water was used in this series of experiments.

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by the appropriate formulæ and the wet bulb in the screen having an adequate water supply). The formula regarded as appropriate for the reduction of the observations in the Stevenson screen is that adopted by the Meteorological Office $e'-e=\frac{4}{5}(t-t'.)$ This is almost identical with Regnault's light wind formula.

The conclusions stated in paragraphs (1) and (3) are satisfactory. As long as there is an adequate supply of pure water to the wet bulb thermometer in the Stevenson screen readings will be obtained for which the accepted psychrometric formula is the right one. Moreover, it is not necessary to use distilled water or rain water, boiled tap water will serve provided that the supply is so generous that the water continually drips.

On the other hand the conclusion stated in paragraph (2) indicates the great importance of avoiding the concentration of salts on the muslin of the wet bulb. Probably there are a good many meteorological stations where the rain water is not clean enough to use in the bottle supplying the wet bulb and where tap water is used as a substitute. The investigation shows that it is a very bad substitute, but that the ill effects are obviated by allowing the water to drip continually from the wet bulb.

In the *Observer's Handbook* it is stated that hard water should not be used for a wet bulb as lime is deposited from the hard water on the bulb. The case is really stronger than this, since softened water, which contains sodium salts in place of the calcium salts of hard water, would also be unsuitable for wet bulbs. When evaporation takes place from a solution of salts in water, it is pure water that is carried away as vapour, the salts are left behind. As evaporation proceeds the solution becomes richer and evaporation is thereby retarded. So the wet bulb thermometer with a rich solution of salt on the muslin gives readings which are too high. With the water supply so liberal that drips fall from the wet bulb, the enrichment of the solution by evaporation is not appreciable and normal readings are obtained.

At Kew Observatory the water supply to the thermometers in the north wall screen has always been of this liberal character. The water used is boiled tap water. Boiling, as is well known, removes the " temporary hardness " due to carbonate of lime. but the " permanent hardness " due to sulphate of lime as well as other salts remain in the water. Nevertheless, there is no indication that in this instance the salts retard evaporation. Whether the system was adopted deliberately is not on record. Most likely the reservoir was placed high so that the flow of water should suffice to keep the whole of the wet bulb moist in dry weather. That the water actually drips from the bottom of the bulb is a happy accident.

The moral is, however, that any observer who finds it inconvenient to use distilled water should arrange for a continuous drip from his wet bulb.

Bottles designed to give a supply of water at a constant level can be obtained from the Meteorological Office. The only drawback is the heavy risk of breakage by frost. This risk may be obviated by passing a rubber tube through the neck of the bottle, the tube being filled with air. This arrangement looks rather clumsy, however, and I hope that some alternative will be invented.

I should like to learn whether the dripping wet bulb has been tried at any meteorological stations near the coast. It has been demonstrated frequently that the deposit of salt from spray makes subsequent wet-bulb readings useless. The evil might be reduced considerably if the thermometers had a liberal supply of distilled water.

F. J. W. Whipple.

Observations of Temperature close to the ground on clear calm nights

By E. V. Newnham, B.Sc.

It is well known that on clear and not very windy nights the reading of a properly exposed grass minimum thermometer is generally several degrees below that of the thermometers in the ordinary Stevenson screen. It is natural to suppose that the grass minimum is cooled by radiation below the temperature of the surrounding air, for it readily becomes dewed or covered with hoar frost, and in the latter case the instrument is often heavily coated with ice by sunrise. If it were not for this fact one might suppose that the thermometer indicates the temperature of a shallow layer of air that becomes greatly cooled by contact with the chilled grass. If such a layer were formed, it would tend on account of its density to become impervious to the action of turbulence, and therefore could go on becoming colder without dilution with relatively warm air from above. L. G. H. Dines* has made some comparisons between the readings of a grass minimum thermometer set an inch above short grass and those of an aspiration psychrometer set with its air intake at the same height. The psychrometer readings were found to be higher; the mean difference was as much as 3°F. on a number of occasions when the average reading of the grass minimum was 17°F. Objection might, however, be taken to this method of measuring the air temperature, on the ground that most of the air entering the psychrometer may have come from a higher level.

It seemed possible that by using mercury thermometers with

*See *Meteorological Magazine*, 59, 1924 p. 12.

very small bulbs an approximation to the lapse-rate of temperature in the first few inches above a grass lawn on clear still nights might be obtained, perhaps even an approximation to actual air temperatures. Accordingly, numerous sets of observations were made during the very cold nights of February and early March, 1929, with six mercury thermometers having cylindrical bulbs of from $2\frac{1}{2}$ to 4 mm. diameter. They were mounted horizontally at right angles to a slender wooden rod drilled to receive them, and a fine metal point at the end of the rod allowed of its erection on a lawn, which was covered with good turf one inch thick. In the table some typical readings, corrected for index error, are given. It should be noted that heights are measured from the ground underlying the grass; the reading $T_{1''}$ is for about the level most appropriate for a grass minimum thermometer, if the purpose of that instrument is to indicate the region of lowest temperature—*i.e.*, for the level of the tips of the grass blades. $T_{1''}$ was always observed to be a degree or two higher than the temperature indicated at the same instant by two standard grass minimum thermometers set at the same height a few feet away; the latter soon became dewed, whereas the small thermometers very rarely were, and it can be assumed that the latter gave readings more nearly corresponding with true air temperature. The readings were made lying flat on the ground, from behind a small wooden screen, to shield the thermometers from any radiation from the observer's body, but this was eventually found to be unnecessary.

It is only to a very limited extent that the figures in the table speak for themselves; to try to understand the physical processes at work it is necessary to take note of things that could not be measured with any apparatus available. An important point is that these rather sensitive thermometers were generally observed to give incessant variations, often rising or falling a degree in a minute or less, except when the bulb was set below the top of the grass. The calmest possible nights were chosen; usually the drift of cigarette smoke along the grass was of the order of $\frac{1}{2}$ m.p.h. or less, but on rare occasions when a slight air movement could momentarily be felt, all thermometers above the grass would at once rise a degree or two, soon recovering their lower readings again afterwards, and it seemed likely that even the smaller and nearly incessant variations were caused by a turbulence of the air that one would not have expected under such conditions. This turbulence was evident on comparing the rapid dispersion of a small puff of smoke on the grass with the very leisurely dispersion of a similar puff in a closed room with no fire. The manner in which the smoke puff was dispersed was not such as might have been expected merely from the instability of the warm cloud in its cold surroundings. It is difficult to give a correct impression of the process in words.

When the obvious disturbance caused by expelling the smoke cloud had died down and the latter lay nearly motionless or drifted very slowly over the grass, an irregular turbulent movement could be seen that did not appear to be dying down and which so scattered the smoke that the puff could not be followed for more than about 5 or 10 seconds. Such free interchange of air over the first few inches of height appears incompatible with the idea of a strong stratification of the air in question into layers of different temperature, such as the readings appear to indicate, and it was therefore concluded that the thermometers, in spite of their general freedom from dew, were not indicating even approximately the true mean air temperature at the same level. It was observed that on those occasions when perceptible light airs were noticeable at times along the grass, $T_{\frac{1}{2}}$ was only slightly affected, if at all, and on a few nights when there was a sustained air drift, $T_{\frac{1}{2}''}$ was the lowest reading, e.g., on March 9th with a drift of nearly 2 m.p.h. $T_{\frac{1}{2}''}$ was from 3° to 4° below $T_{1''}$. The observations of Aitken* and Franklin‡ show, however, that at a lower depth in the grass much higher readings are to be expected. The figures for the surface earth temperature (the thermometer bulb just covered by the earth underlying the grass) for February 14th-15th given in the table, may be noted in this connexion. Returning to the question as to how nearly the thermometers indicated air temperature, one of them was used as a sling thermometer, and was whirled in a horizontal plane, but risk of breakage made it impracticable to do this in the most interesting region just above the grass tips. On February 14th at 11—11.30 p.m., in an estimated wind of 1 m.p.h. $T_{5''}$ by sling thermometers was 1° higher than $T_{5''}$ on the stand, and in a lighter wind (about $\frac{1}{2}$ m.p.h.) there was a difference of 1·1° for $T_{10''}$. Even in a comparatively strong wind reaching 6 or 7 m.p.h at times (on March 1st, 11.15—11.30 p.m.) $T_{5''}$ by sling was 0·5° to 0·6° higher than $T_{5''}$ on the stand. It was found that encasing the thermometer bulbs with polished German silver shields, leaving an air space between the shield and the bulb, seemed to have no effect on their readings, and a difference of 1·1° was noted on March 9th, 1929, in a 2 m.p.h. wind, between whirled and stationary shielded thermometers at $5\frac{1}{4}$ inches. This result is in accordance with Aitken's observations† that most common substances including polished metals and blackened metal appear to radiate equally well at temperatures such as those that we are dealing with.

General Conclusions.

If the interpretation of the behaviour of smoke over the grass

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* "On dew", *Collected Papers*, pp. 139 and 142.

‡ "The cooling of the soil at night", *Proc. Royal Soc. Edinburgh* XXXIX, p. 120.

† "On dew", *Collected Papers*, pp. 160-5,

TABLE I—READINGS OF SMALL MERCURY THERMOMETERS ON CLEAR NIGHTS.

The suffixes 1″, 3″, etc., refer to height above solid ground; subtract one inch to get height above tips of grass blades.

	TIME G.M.T.	$T_{1''}$	$T_{3''}$	$T_{5''}$	$T_{7''}$	$T_{9''}$	$T_{11''}$
	h. m.						
Feb. 3rd, 1929. Very dry air. Wind at chimney level about 5 m.p.h. from between E. and N. Perceptible air movement along ground from N.	19 00	26·2	28·2	28·6	28.7	28·7	28·8
	22 00	25·2	28·4	28·3	28.4	28·5	28·4
	22 10	25·2	28·0	28·4	28.7	28·7	28·7
	22 25	24·1	27·5	27·8	28.3	28·8	28·8
Feb. 8th, 1929. Not quite so dry. Light easterly airs at chimney level, increasing. Perceptible movement along ground as often from S. as from N. All thermometers dewing very slightly.	23 47	26·3	28·1	28·2	28·7		28·8
	23 52	26·7	28·2	28·5	28·7		29·1
	24 13	26·0	27·5	28·2	28·6		29·0
	24 30	26·6	28·1	28·5	..		28·8
	24 37	27·6	29·6	30·3	30·9		31·3
	24 42	27·2	30·7	30·7	30·9		31·2
	24 44	28·7	30·3	30·7	30·9		31·3

	TIME G.M.T.	$T_{\frac{1}{2}''}$	$T_{1\frac{1}{2}''}$	$T_{3''}$	$T_{5''}$	$T_{10''}$	T_{earth}
	h. m.						
Feb. 13th-14th, 1929. Wind at chimney level NNE. increasing gradually to about 10 m.p.h. Perceptible movement along the ground mainly from E. shows how increase of wind may cause lowest reading to be below tips of grass blades.	22 14	12·4	12·8	13·5	13·8	13·9	
	22 17	12·4	12·8	13·4	13·7	13·8	
	22 20	12·7	13·3	14·2	14·3	14·4	
	22 45	13·1	8·8	12·9	13·3	13·4	
	22 48	12·4	8·8	12·4	12·9	13·3	
	3 59	14·1	15·3	15·6	15·8	16·2	
	4 1	14·1	14·8	15·2	15·6	15·7	
	4 2	14·1	14·7	15·1	15·3	15·4	
	4 4	14·0	14·8	15·2	15·5	15·7	
	4 5	14·1	15·2	15·4	15·7	15·8	
Feb. 14th, 1929. Wind at chimney level W.-NW. 3-4 m.p.h. Tendency for drift from S. and SE. along the ground.	22 54	12·0	12·7	13·2	13·8	14·3	(20·4)
	22 56	12·1	12·7	13·7	14·2	14·4	
	22 59	12·0	12·2	13·2	13·7	14·2	
	23 1	12·1	12·8	13·5	14·3	15·0	(20·3)
	23 28	10·9	11·2	11·8	11·9	12·2	
	23 30	11·2	10·8	11·8	12·2	12·3	(20·2)

given above is correct, considerable turbulence appears to be usual close to the ground in a suburban garden even under a clear night sky in quiet weather when conditions would appear to be most favourable for a high degree of stratification. When, however, it is considered that at such times every solid object is tending to cool several degrees below the temperature of the surrounding air, this is perhaps not surprising, for every such object must be a continual source of descending air currents.

It would be interesting to have more accurate information as to what happens not only in suburban surroundings but in open country. If sensitive electrical resistance thermometers could be employed the true air temperature might be measured, and the fine wire of such thermometers would presumably not introduce any appreciable disturbance of natural conditions. The designing of apparatus sensitive enough for measuring small scale turbulence might, however, prove difficult.

The rough experiments described in this note seem to suggest that the definite instruction, in the official handbooks that appeared before the modern "Observers' Handbook," to set a grass minimum thermometer so as just to touch the tips of the grass blades, might be re-introduced with advantage as a step towards getting comparable observations from different stations, and an even greater degree of comparability would result from the employment of a "radiation box" as advocated by Aitken.† It might of course be argued that the object of grass minimum readings is to get information as to what degree of cold plants are subjected to, and not measures of terrestrial radiation, but very little vegetation is so situated as to experience such a degree of cold as the upper part of thick turf, and it is a matter of common observation that plants readily injured by frost normally survive a night with a sharp "ground frost," as indicated by the "grass minimum," so long as the temperature in the screen does not fall below 32°F. For these reasons it might be better to make the measurement one of terrestrial radiation. In any case the use of the term "ground frost" in connexion with grass minima is unfortunate, for the influence of the ground appears to be all in the direction of preventing frost owing to its being a moderately good conductor of heat and, on clear nights, having normally a temperature much above that of the overlying air.

Royal Meteorological Society

The monthly meeting of this Society was held on Wednesday evening, March 19th, at 49, Cromwell Road, Mr. R. G. K. Lempfert, C.B.E., M.A., F.Inst.P., President, in the Chair. As is customary in March, the meeting took the form of a lecture (The Symons Memorial Lecture), which was delivered on this

† "On dew," *Collected Papers*, pp. 158-9.

occasion by Dr. Herbert Lapworth, M.Inst.C.E., his subject being

Meteorology and Water Supply.

The lecturer dealt mainly with the story of the rain between its precipitation as rainfall on the surface of the ground and its later appearance in the form of streams, springs and underground water, that is to say, a brief outline of the sciences of hydrology and hydrogeology as bearing upon the preliminary investigation of the water-engineer.

It was pointed out that precision in water-supply problems can only be obtained by the collection of data in these two sciences and in rainfall statistics. The lecturer stated that water-engineers started from the basis of rainfall, the laws of flucuation of which were regarded by the water-engineer as more precise than the laws of hydrology and hydrogeology. Nevertheless the preliminary investigations of water supply were based upon nineteenth century rainfall observations, whereas there was good evidence that in the previous century there had been longer and worse droughts than any which had occurred during the period covered by the observations. If such conditions recurred probably no waterworks in Britain could adequately meet them. After discussing the driest years, on which basis waterworks were designed, the lecturer dealt with floods and stream flow in general, reviewing the relation between rainfall and run-off and the losses due to evaporation and other causes in streams and underground water. The movement of underground water, the formation of springs and the fluctuation of water-level were then described, including references to bournes and disappearing streams and rivers. The question of wells and the effects of pumping were then treated, and the artesian basins of the world were briefly noted, illustrating the immense distances travelled by underground water. Finally, the lecturer paid tribute to Drs. Symons, Mill, Salter and others for their investigations on British rainfall, an arduous task carried out under great difficulty, but of immense value to the profession of the water-engineer.

Correspondence

To the Editor, *The Meteorological Magazine.*

Low March Temperatures

The following may be of interest to you. On the morning of March 20th my grass minimum thermometer showed 30° of frost and that in the screen 19° of frost. This is the lowest reading I can remember here in March. We had also 4 inches of snow. Both thermometers are by Negretti & Zambra.

R. G. C. Sandiman.

Dany Parc, Crickhowell, South Wales. March 21st, 1930.

Abnormal Vertical Air Currents

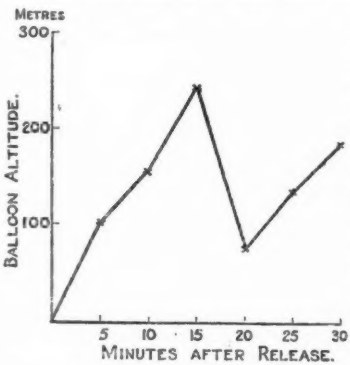
An example of a strong descending air current was observed during a pilot balloon ascent on December 18th, 1929. A moderate breeze was blowing with the sky 0·6 overcast.

The balloon, weighing 20 gm., was inflated according to the Dines formula to ascend at 150 m./min. The height of the balloon was determined by both the range-finder and the tail method. The results of the flight are given in Table I :—

TABLE I.—PILOT BALLOON OBSERVATION SHOWING ABNORMAL DESCENT.

Time	Altitude			Wind	
	Tail Method	Range Finder	Mean	Velocity	Direction
min.	m.	m.	m.	m./sec.	°
0·0	—	—	—	13·4	315
0·5	102	122	112	8·8	317
1·0	166	143	154	14·1	336
1·5	252	232	242	12·6	337
2·0	78	69	74	15·6	336
2·5	137	130	134	13·7	336
3·0	185	179	182	9·6	338

From Fig. 1 showing the altitude of the balloon at half-minute intervals it is seen that the balloon should have reached



an altitude of 300 m. at the end of the second minute. The observed height was only 74 m. In half a minute the balloon actually fell a distance of 168 metres. This indicates a downward air current with a velocity of 486 m./min., or 8·1 m./sec. After this gust the balloon rose at approximately the normal rate of ascent until lost in scud in the following minute. In general, rates of ascent below normal are observed when balloons are released during a gust, but above normal if released in the lull following the gust.

The altitudes given in Table I show the nature of agreement obtained under adverse observing conditions with tail and range-finder methods of determining the height of pilot balloons.

ANDREW THOMSON.

Mete rological Office, Wellington, New Zealand.

The Atmosphere as a Colloid

In the September issue of the *Meteorological Magazine* Dr. F. J. W. Whipple, reviewing " Die Atmosphäre als Kolloid " of Schmauss and Wigand, refers on page 194 to the experience of Major Holtzey of Lindau, looking down on a sea of mist over the Rhine Valley. This was so shallow that church towers stood out above it. It was cloudless overhead. " On the return journey the party walked into the mist and after ten minutes they were soaked through with rain." Dr. Whipple asks, " Can a parallel be found for this experience? It is surely inconsistent with all current ideas as to rain formation to assume that the rain-drops developed in the low-lying mist."

The following example shows a rather unusual condition of liquid drops in a fog at Blue Hill Observatory. The preceding 24 hours were warm with much haze, and a typical Indian Summer day. Surface temperature in afternoon 19°C., relative humidity 60 per cent., absolute humidity 10 grams per cubic meter of space, temperature of condensation 11°C, height of base of small cumulus clouds 1,200 meters, surface wind, SW, velocity 10 meters per second, velocity of cloud 16 m/s moving from W.

This condition was followed by a veering of the wind to NE by N velocity 4 m/s, temperature 10°C., vapour pressure 12·3 kilodynes per square centimeter (or millibars), saturation weight 9·4 grams per cubic meter, resulting in fog containing a large number of liquid particles. A screen of fine mesh, at right angles to the flow of the fog caught in a short time, a large number of drops, average surface area of drops, 12 square millimeters. The droplets were carried along horizontally. A screen in fog but sheltered from the flow did not show any drops. It seems like a clear case of condensation and further deposition on the haze particles.

Fogs of this type in this vicinity, under anticyclonic regimen, are, as a rule, shallow, often only 200 meters in depth. On December 14th, 1929, 11 a.m., fog covered New York City, but being only 100 meters in thickness it was pierced by the tops of the tall buildings.

ALEXANDER MCADIE.

Harvard University, Blue Hill Observatory, Readville, Mass. February 20th, 1930.

Minimum Temperatures on "Radiation Nights"

In the *Meteorological Magazine* for December, 1927 (p. 260), one of us, in conjunction with Mr. J. Paton, gave approximate equations connecting the screen and grass minimum temperatures recorded in " winter " (October to March, inclusive) at Cranwell, Lincolnshire, on " radiation nights." It has since been thought that a similar piece of work for a sea-coast station was called for, for the purposes of comparison. Calshot was the station chosen. The period examined stretched from October 1st,

1923, to March 31st, 1928, a " radiation night " was defined as in the previous note as one in which the mean cloud amount at 18h., 1h., and 7h. G.M.T. was four-tenths or less, and the screen and grass minimum temperatures were those measured at the last mentioned 7h.

In determining the equations representing the relationship a two-fold differentiation was made with regard to wind speed during the night, as measured by a Dines anemometer whose head is 43 feet above ground level, taking the average of the readings at 18h., 1h., and 7h., as criteria, and then each such wind group was further sub-divided according as to whether the relative humidity at the preceding 15h. G.M.T. was less than 85 per cent or no.

Using T as the screen minimum temperature and G as the grass minimum temperature, the four equations found were as follows :—

Mean Wind Speed	Relative Humidity at 15h.	Equation	No. of cases
8 miles per hour or less	> 85	$T = 1.5G - 10.0$	8
	$=$ or < 85	$T = 1.1G + 5.6$	51
Greater than 8 miles per hour	> 85	$T = G + 3.8$	35
	$=$ or < 85	$T = G + 6.7$	146

Comparing the results for Cranwell, the inland station and Calshot, the sea-coast station, the main result appears to be that for low wind speeds (8 m.p.h. or less) the difference between the two minima is greater at Calshot than it is at Cranwell. For the higher wind speeds no such general result can be stated.

W. H. Pick.
D. F. Bowering.

Halo and Parhelia

This afternoon the halo of 22° and its parhelia were observed at 15h. The halo itself was very faint but it was quite possible to see the gap separating it from the two parhelia. These latter showed prismatic colours and at first were quite faint, but about 15h. 3m. became much brighter. Before observations ceased about 15h. 15m. the halo had faded, leaving the parhelia. The parhelia had no " tails."

Halo phenomena seem to have been frequent this month, solar halos being noted on the 6th, 17th, 18th and 20th, and lunar halos on the 10th and 11th.

Cicely M. Botley.

Guildables, 17, Holmesdale Gardens, Hastings. March 20th, 1930.

NOTES AND QUERIES

Formation of Fog in Lower Egypt on October 29th and 30th, 1929.

A very good illustration of the principles underlying fog formation occurred in Egypt on October 28th, 1929, prior to the formation of dense fog over the Cairo, Helwan, Abu-Sueir, Ismailia district on October 29th and 30th, 1929.

An intense anticyclone (1,038 mb.) was centred over eastern Russia and extended its influence southwards over the eastern Mediterranean, Egypt, Palestine and Transjordan. In Palestine and Transjordan winds were SE'ly 15-25m.p.h. and in Egypt NE.-ENE. 30-35m.p.h., decreasing with height. The synoptic

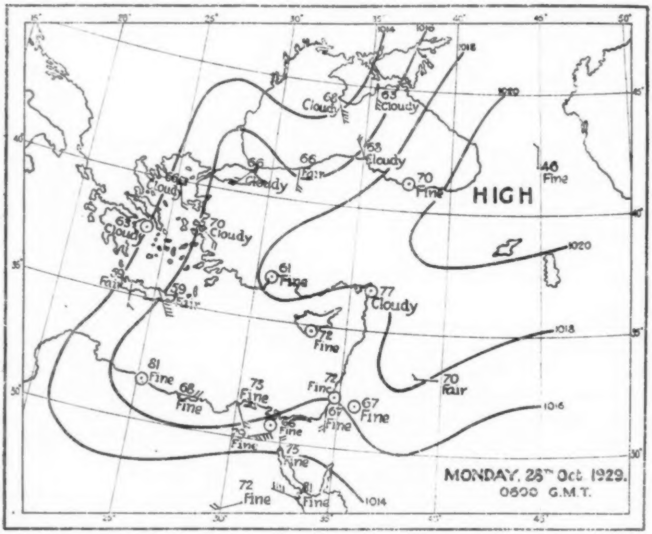


chart for 6h. G.M.T. on October 28th is reproduced. At this hour the wind at Ismailia was calm, temperature 66°F. and humidity 82 per cent., while at Heliopolis the wind was ENE. force 5, temperature 79°F. and humidity 31 per cent. Such striking differences in wind, temperature and humidity at two places situated apparently in the same air stream can be explained as follows:—

Air descending in the old established anticyclone to the east flows off on a gliding surface which slopes downwards towards south and southwest.* This gliding surface cuts the ground

* For a discussion on these gliding surfaces and their relation to fog formation *see* W. Georgii. Ann. Hydrogr., Berlin, XXXXVIII, 1920, p. 207.

between Ismailia and Heliopolis, probably very near the latter place. The high temperature and low humidity at Heliopolis result from the heating of the air as it descends this gliding surface. The essential condition for fog formation, viz., the temperature inversion, is therefore present in a very striking fashion. Fog will form in the cool air beneath the gliding surface whenever the NE'ly wind becomes sufficiently damp and sufficiently cooled by nocturnal radiation. This did not happen on the 28th at Ismailia, although the humidity at 3h. G.M.T. was 94 per cent. (compared with 44 per cent. at Heliopolis). On the 29th Heliopolis was no longer in the warm upper zone (the surface having moved further south) and thick fog resulted over a considerable area.

Very similar conditions were recorded at 6h. G.M.T. on November 18th, 1929.

	Heliopolis.	*Ismailia.*
Wind	Force 4	Calm
Temperature	66°F.	57°F.
Humidity	73 per cent.	100 per cent.

In this case fog had actually developed at Ismailia on the 18th, but it occurred extensively from November 19th-21st after the gliding surface had moved further south and west.

J. Durward.

Hurricanes in the Fiji Islands

The "hurricane season" of the Fiji Islands occurs in the summer months of the southern hemisphere. In each season, on the average about one hurricane is experienced; occasionally the track traverses the group of islands, but usually it recurves round the western point of the group.*

Observations relating to two recent hurricanes have been passed to the Meteorological Office by Captain E. W. G. Twentyman, M.B.E., who is in charge of the meteorological work at Suva, Fiji. The first occurred on December 10th-13th, 1929. Frequent extra observations besides the usual daily pair of climatological observations were made at Suva, and from these it appears that the hurricane centre passed through the Fiji group. On December 10th, strong winds from ESE. were experienced, with heavy rain. On the 11th a gale blew from south-east during most of the day, in the early morning of the 12th a veer to south occurred and the wind increased to force 11 on the Beaufort Scale, a velocity of 74 m.p.h. being recorded by the pressure tube anemometer at 3h. 5m. (zone time). Later the wind veered to SW. and decreased somewhat, but blew with gale force during most of the day. In the 24 hours ending at

*Compare the description of a hurricane at Suva in the *Meteorological Magazine*, 64, 1929, p. 168.

8h. 30m. on the 11th slightly over 11 inches of rain fell. Captain Twentyman hopes to prepare a detailed report on the storm when observations from other islands are collected.

The second hurricane occurred on January 11th-12th, 1930. Observations have been collected from a few outlying stations which enable the approximate track to be deduced as passing over the islands of Mokongai, Wakaya and Ngau, during the night of the 11th and early morning of the 12th. The hurricane, while causing winds to reach force 11-12 at places over which the centre appears to have passed, lasted only about three hours; and the rate of travel appears to have been a little under 10 m.p.h. The centre probably passed within about 50 miles of Suva, where the storm was not felt. It is interesting to note that a prolongation of the track of this storm passes near the island of Totoya, where a hurricane was experienced on December 11th-12th, 1879.

S. T. A. Mirrlees.

Old Weather Diaries, Goodwood House, 1798—1806

His Grace the Duke of Richmond and Gordon, M.V.O., has been good enough to present to the Meteorological Office an interesting and valuable weather record maintained at Goodwood House, Sussex, from 1798 to 1806. The volume for 1801 is unfortunately missing, but the record is otherwise practically complete from January 1st, 1798, to December 29th, 1806.

Observations of pressure, temperature and wind are given three times daily, at 8 a.m., 2 p.m., and 8 p.m. Rainfall was measured daily at 8 a.m. from February 14th, 1798, onwards, and daily notes on the weather are also given. For the greater part of the period readings from two different barometers and three thermometers are entered. For "Barometer No. 1," made by Ramsden, readings of the attached thermometer are also given. All the observations are entered in a beautifully clear "copper-plate" hand, and the whole record is in an excellent state of preservation.

The volume for 1798 opens with a detailed description of each instrument with full particulars of its exposure. The two barometers and three thermometers were carefully inter-compared and the results are tabulated. Unfortunately no details of the raingauge and its exposure are given.

Thanks are due to Mr. S. Capon, Goodwood Gardens, for bringing this record to the notice of the Office.

A Simple Equation for Heavy Rainfalls in Short Periods

In *British Rainfall* special mention is made of all falls of rain of 2 hours or less reaching an intensity referred to as "noteworthy." This classification is effected by reference to a diagram which indi-

cates by a continuous curved line the lower limits of rainfall which must fall in stated periods so as to be classified as "noteworthy," for example, a fall of 1·23 inch or more in 2 hours, 1·00 inch or more in 1 hour, 0·70 inch or more in 30 minutes, 0·43 inch or more in 15 minutes and 0·20 inch or more in 6 minutes. I have noted recently that the simple equation $i = \frac{100}{t + 40}$ (where i is the intensity in inches per hour and t is the time in minutes) represents closely this limiting intensity.

Heavy falls in short periods are of particular importance to those who deal with the disposal of flood water, and in the numerous papers on the subject, it is usual to connect the intensity of the rain and the duration of the storm by equations either of the form $i = \frac{k_1}{t + k_2}$ or $i = k_1 t^{k_2}$ where k_1 and k_2 are constants. My own experience is that the former type of equation is a closer approximation to the observations for the British Isles. The equation $i = \frac{100}{t + 40}$ gives values for the rainfall for all values of t up to 120 minutes, within 0·03 inch of the curve of limiting values of "noteworthy" falls given in *British Rainfall.*

During the last 60 years the mean number of "noteworthy" falls reported from all the observing stations over the British Isles has been only about 34 a year. Thus, such falls at any particular station are rare. It is only at stations where recording rain-gauges are in operation that all such falls can be detected, special readings before and after the storm having to be made at stations with ordinary gauges. Most stations in England and Wales with recording gauges have experienced three such falls in seven years (for $t = 10$, 20, 30 and 60) of an intensity at least equal to that given by the equation $i = \frac{40}{t + 15}$. In this equation the values for i are naturally much smaller for similar values of t than in the previous equation.

The enunciation of a simple equation defining "noteworthy" falls may be especially helpful to observers who have the opportunity of adding to our records on this subject but to whom the diagram is not readily available.

J. GLASSPOOLE.

A Suggested Annual Recurrence of Short Periodicities

In the introduction to the *Report and Results of Observations of the Fernley Observatory, Southport,* for the year 1928, Mr. J. Baxendell gives an account of the further progress of his research into periodicities. The interesting experiment was tried of examining the frequency of cold winds (N., NE. and E.) at Marchside separately for each of 30 years. The results for the

individual years differ greatly, but the final curve, for the thirty combined, shows maxima near 24, 33 and 38 days. The 33 day periodicity had previously been found in Greenwich temperatures for 1841-50. " It seems difficult to believe that this term can be exactly one-eleventh of a year in length, and so, possibly, it does commence afresh in most years . . . in that case, its operation might go far to account for the remarkable fact that, on the average of very many years, the earlier halves of June, July, August and September are decidedly drier and finer than the later halves."

Climatic Atlas of Japan

The Central Meteorological Observatory, Tokyo, has issued a very fine series of charts and tables under the title *Climatic Atlas of Japan and her Neighbouring Countries.* In the preface it is pointed out that thirty years have passed since the previous publication of climatic charts from Japan and during that period a very rich supply of material has become available, including hourly or four-hourly data for about one hundred stations. The new charts are based on observations for the thirty year period 1897 to 1926, except the rainfall charts, which refer to the interval 1901 to 1925.

The charts cover the Japanese Islands, southern Saghalien, Korea and Formosa, and the neighbouring parts of Manchuria and China. They are 95 in number, artistically printed in several colours, and the registration is remarkably accurate. All elements are represented, including temperature, pressure and winds, humidity, cloudiness and sunshine, number of clear and cloudy days, dates of first and last frosts and falls of snow, and evaporation. The charts are followed by 27 pages of tables giving normal values.

Reviews

The Growth of the World and of its Inhabitants. By Professor H. H. Swinnerton, D.Sc. 7½ × 5 in. pp. 208, *Illus.* London: Constable & Co., Ltd., 1929. 5s. net.

The main interests of the author of this little book lie in rocks and fossils, and with those aspects of science he deals in a very competent and readable manner. Apart from a chapter on " Water and Air," meteorology enters little into the story, but now and again the part played by climatic vicissitudes is brought before the reader, especially towards the close in the sections dealing with the origin of man. The question of continental drift is discussed without bias, and forms the subject of a useful chapter. Another deals with the " Calendar of the Ages," and it is remarkable that here the author does not once mention the

method of age determination by measuring the products of radio-activity. He gives as a "sober estimate" of the duration of geological time since the beginning of the Palæozoic a total of 96 million years, in contrast with the figures of the order of 450 to 500 million years now current.

Der Europäische Monsun. Eine synoptische Darstellung seiner Erscheinungsformen, seines Verlaufs und seiner Ursachen. By Geert Roediger. Leipzig, Veröff Geoph. Inst. Univ. 2nd Series, Vol. IV, Part 3, pp. 119-177, 1929.

With the approach of summer temperature does not rise steadily over Europe, but passes through a series of waves, each crest and trough being generally higher than the preceding ones. These fluctuations are for the most part obviously caused by the passage of an irregular succession of barometric depressions and anticyclones, causing alternating northerly and southerly winds, but a tendency has often been remarked for some of the major fluctuations to occur at about the same time in most if not all years. These quasi-regular ups and downs of temperature have attained some celebrity in this country as the "Buchan periods." This paper by G. Roediger analyses the phenomena associated with two "cold spells" in Europe, the average dates being May 16th to 20th and June 5th to 15th. The phenomena are attributed to monsoon-like currents of cold polar air which cross Europe at about the dates mentioned, as a result of the summer lowering of pressure in the interior of the continent. The course of events is briefly summarised by the author as follows:—

"1. From the end of April to the end of May, precursor of the monsoon. As high pressure still prevails in Asia, the north-west winds penetrate only to central Europe. The cold periods in May accompany such monsoon precursors. From 1890 to 1909 the average time for these advances is the pentad May 16 to 20."

"2. From 5 to 15 June monsoon inbreak. Asia now has low pressure, while over the North Atlantic Ocean a ridge of high pressure is developed from the Azores to Greenland. Vigorous north-west winds blow across Europe into Asia and cause a marked fall of temperature, accompanied by thunder. The air transport is for the most part from polar regions."

After June 15th the winds blow from WNW. and consist principally of equatorial air which has travelled for a long distance over the sea, consequently there is an increase of rainfall. The change from summer to winter monsoon in autumn is marked by a warm spell in September, the "old wives summer."

The changes in wind direction, temperature, humidity, cloudiness and rainfall associated with the European monsoon are worked out in great detail with the aid of five-day means for a

number of places, generally based on averages for periods of twenty years. Some well-marked individual cases are investigated by means of synoptic charts. The author recognises that there are often great irregularities in individual years, and that the "European monsoon" is only a secondary factor, but claims that its part in the determination of the sequence of weather changes is not without importance.

Beitrag zur Langfrist-Wettervorhersage. By F. B. Groissmayr. Ann. Hydrogr. Berlin, 1928, pp. 287-93 and 310-7.

The main interest of this pair of papers is the influence of Charleston rainfall on world weather, and I have prepared a note which follows in criticism. The following are some of the coefficients which Prof. Groissmayr gets with Charleston rainfall:— + 0·64 with Charleston rain next year, + 0·61 with the Nile 2 years later, − 0·66 with Azores-Iceland pressure December to February 2½ years later, in each case based on about 50 years of data. He also connects the autumn temperature of the eastern United States with Argentine pressure in May preceding.

Note on Charleston Rainfall and its Relation to World Weather. —In view of the surprisingly large coefficients obtained by Prof. Groissmayr with a single raingauge at Charleston it seemed advisable to try whether the results would be equally shown by the rainfall indicated by the raingauges of the neighbourhood. From the *Summaries of Climatological Data by Sections** I selected a number of such stations and correlated their rainfall with the Nile 2 years later as follows:—Hatteras 0·42, Pinopolis 0·24, Savannah 0·36, Wilmington 0·40: further, the mean of the seven stations Jacksonville, Savannah, Augusta, Southport, Wilmington, Charlotte and Pinopolis gave the coefficient 0·42 with 50 years of data. It may be concluded, therefore, that the relationship 0·60 with Charleston is fictitiously big.

Another test may be applied by extending the data still further back and a graphical comparison of the period 1834-1870 does not show a particularly close relationship.

It is also of interest to correlate with the Nile at intervals other than that of 2 years chosen by Prof. Groissmayr. With Carolina rainfall and the Nile of the same year the coefficient is 0·20, with the Nile one year later 0·34, 2 years later 0·42, 3 years later 0·42 and 4 years later 0·28, so that there is a good deal of persistence probably due to slow changes common to both factors.

The above tests were made at the suggestion of Sir Gilbert Walker.

E. W. Bliss.

* *Washington. Bulletin W. 2nd edition,* 1926.

Books Received

Zur Bedeutung des Voltaeffektes für Raumladungsmessungen nach der Thomson'schen Methode. By F. Lindholm and M. Bider (Helvetica Physica Acta. Vol. I, Fas. 9).

Bibliography of Meteorological Papers in the publications of the Asiatic Society of Bengál, 1788-1928. By V. V. Sohoni, Jour. and Proc. Asiatic Soc., Bengal. (New Series), XXIII, 1927, No. 3.

News in Brief

The Council of the Royal Society of Arts has awarded, the prize of £150 which they offered in 1929 under the Thomas Gray Memorial Trust for an improvement in the science or practice of navigation, to Dr. A. T. Doodson, Associate Director of the Liverpool Observatory and Tidal Institute for his work on the analysis and prediction of tidal currents.

According to *The Times* an Arctic expedition, under the leadership of Professor Alfred Wegener of Graz University, has left Berlin for Greenland, where it is proposed to spend some 18 months exploring the interior.

The Weather of March, 1930

The weather of March was very variable, generally mild and cloudy at first, then cold and snowy, and finally mild and sunny. Fine warm sunny anticyclonic conditions prevailed for the first two days of the month, and temperature rose generally to above 50°F., reaching 55°F. at Fort Augustus and Kilmarnock on the 1st and 61°F. at Tottenham on the 3rd. There was much mist or fog locally in the mornings and evenings. Fair conditions prevailed in the eastern districts for some time after this, but a shallow depression centred off our south-west coasts brought rain in the west on the 4th, which spread north later. On the 6th a trough of low pressure passed eastwards across the country and rain was general. Among the heaviest falls were 1·17in. at Tyn-y-waun (Glamorgan) on the 6th and 0·72in. at Rothesay on the 5th. Mild anticyclonic conditions were re-established on the 7th and 8th, except in the extreme north. On the 9th a complete change occurred; the large area of low pressure (with several centres) over northern Europe and Greenland extended southwards over the British Isles, and the air supply over this country was derived from the Arctic. Cold, unsettled wintry weather prevailed with rain, sleet and snow at times. Heavy snow was general over Scotland, north Ireland and north England from the 10th to 23rd, and also occurred in south England on the 19th and 20th. 4in. were measured at Durham on the 16th, 5in. at Rhayader on

the 19th, and 9in. at Aspatria on the 18th. Precipitation measurements were heaviest on the 14th, 15th, 16th and 19th, *e.g.*, 1·30in. at Goytre Hall (Monmouth) on the 14th and 1·31in. at Barnsley (Yorkshire) on the 15th. Night temperatures in the screen were frequently below 30°F. and as low as 12°F. at Eskdalemuir on the 20th, while ground minima fell to 10°F. at Armagh on the 19th and 3°F. at Ross-on-Wye on the 20th. Day temperatures did not rise above 32°F. in parts of north Scotland and the English Midlands on the 19th. The 22nd was a very sunny day, over 10hrs. bright sunshine being recorded locally, but the 23rd was again wet in the south. By the evening of the 23rd warm southwesterly winds in the rear of a ridge of high pressure reached Ireland. The warmth spread north and east, reaching southeast England on the 25th, but the snow had not disappeared from Scotland until the 26th. The weather continued warm until the end of the month, but during the last few days deep depressions on the Atlantic moving northeast caused moderate rain locally on a few days and gales at exposed places on our western coasts on the 28th. The 24th, 26th and 29th, however, were very sunny days, 11·1hrs. of bright sunshine being recorded at Plymouth on the 26th and at Oxford on the 29th. The total rainfall for the month was above normal, except in north Scotland and south and east England. The distribution of bright sunshine for the month was as follows:—

	Total (hrs.)	Diff. from normal (hrs.)		Total (hrs.)	Diff. from normal (hrs).
Stornoway	122	+17	Liverpool	98	—10
Aberdeen	141	+24	Ross-on-Wye	104	—12
Dublin	99	—24	Falmouth	132	— 6
Birr Castle	86	—24	Gorleston	133	— 2
Valentia	105	—18	Kew	122	+17

Pressure was below normal over the North Atlantic and western Europe, except for the Iberian Peninsula, Italy and Iceland, the greatest deficit being 7·1mb. at Rost and the greatest excesses 6·2mb. at Isafjord and 2·6mb. at Madrid. Temperature was above normal generally over western Europe, being as much as 5°F. in excess in southern Norrland and eastern Svealand, but below normal in Scotland, Ireland and Spitsbergen. Precipitation was in excess over the northern part of Scandinavia being twice the normal in Lapland but deficient in Spitsbergen and central Europe.

High temperatures were experienced in south Iceland during the beginning of the month, 55°F. being registered at Seydisfjord at 18h. on the 1st. The river Hvita overflowed its banks on the 3rd, inundating a large area of the Floi Lowlands. The floods had passed their peak by the 5th, but the roads were impassable for several days. As a result of the heavy rain and relatively high temperature severe floods were experienced in

south France during the first half of the month.* These were subsiding after the 6th, but heavy rain in southwest France about the 12th extended the flood area to the Bayonne district. The floods continued to spread slightly until about the 19th, when they had mostly disappeared. In all 206 people were drowned. Warm rain having melted the snow on the south side of the Pyrenees, the Ebro rose 20ft. above its normal level on the 14th. The peak of the flood reached Saragossa at 6h. on the 15th. Many cattle were lost. A strong Föhn wind which arose after violent thunderstorms on the 15th swept across Switzerland, causing widespread damage and many avalanches. Snow fell heavily all over Switzerland on the 19th, reaching a depth of nearly 2ft. at a level of 4,000ft.

The floods in the desert in Western Australia continued until about the 4th. Heavy monsoon rain also fell in central and northern Australia at the beginning of the month. Beneficial rain fell during the month over the north coast, the northern Riverina and the greater part of the wheat belt of New South Wales.

A tornado caused much damage at Los Angeles, California, on the 15th, but there was no loss of life. Cold weather was experienced at the beginning and end of the month in the United States, but between about the 6th and 18th the temperature was generally moderate except in the northeastern districts, where it was exceptionally warm, 70°F. and above being recorded on one or two days at a few places. Rainfall was generally moderate. A severe snowstorm, however, occurred over the area between Nebraska, Pennsylvania, the Great Lakes and the Tennessee mountains on the 26th, 19in. of snow were reported in Chicago. About 400yds. of the Leopoldina railway track and several bridges were washed away at Petropolis near Rio de Janeiro, the result of a severe storm on the 24th, and floods occurred at Selva San Andres on the Pilcomayo, Argentina, on the 26th.

The special message from Brazil states that the rainfall was generally scarce, the average being 0·24in., 0·51in. and 0·75in. below normal in the northern, central and southern regions respectively. Eight anticyclones passed across the country. The crops were generally affected by the lack of rain during the last three months, though cotton was improving with the increased precipitation during the last days of March. At Rio de Janeiro pressure was normal and temperature 1·3°F. above normal.

Rainfall, March, 1930.—General Distribution

England and Wales	102	per cent of the average 1881-1915.
Scotland	78	
Ireland	146	
British Isles	106	

* *See Meteorological Magazine* 65 (1930), p. 43.

Rainfall: March, 1930: England and Wales

Co.	Station	In.	Per-cent of Av.	Co.	Station	In.	Per-cent. of Av.
Lond .	Camden Square	1·60	87	*Leics* .	Belvoir Castle	1·58	87
Sur .	Reigate, Alvington	2·07	88	*Rut* .	Ridlington	1·83	...
Kent .	Tenterden, Ashenden	1·84	82	*Linc* .	Boston, Skirbeck	1·66	106
,, .	Folkestone, Boro. San.	2·49	...	,, .	Cranwell Aerodrome	2·18	156
,, .	Margate, Cliftonville	1·77	111	,, .	Skegness, Marine Gdns	1·37	83
,, .	Sevenoaks, Speldhurst	1·88	...	,, .	Louth, Westgate	1·94	92
Sus .	Patching Farm	2·01	93	,, .	Brigg, Wrawby St.	1·72	...
,, .	Brighton, Old Steyne	1·67	83	*Notts* .	Worksop, Hodsock	2·27	134
,, .	Heathfield, Barklye	1·80	72	*Derby* .	Derby, L. M. & S. Rly.	2·83	165
Hants .	Ventnor, Roy. Nat. Hos.	1·38	67	,, .	Buxton, Devon Hos.	2·62	63
,, .	Fordingbridge, Oaklnds	1·36	58	*Ches* .	Runcorn, Weston Pt.	3·24	160
,, .	Ovington Rectory	1·44	56	,, .	Nantwich, Dorfold Hall	3·42	...
,, .	Sherborne St. John	1·23	55	*Lancs* .	Manchester, Whit. Pk.	2·65	117
Berks .	Wellington College	1·09	55	,, .	Stonyhurst College	2·85	77
,, .	Newbury, Greenham	·99	44	,, .	Southport, Hesketh Pk	3·11	139
Herts .	Welwyn Garden City	1·54	...	,, .	Lancaster, Strathspey	3·14	...
Bucks .	High Wycombe	1·57	80	*Yorks* .	Wath-upon-Dearne	2·21	127
Oxf .	Oxford, Mag. College	1·13	74	,, .	Bradford, Lister Pk.	2·90	119
Nor .	Pitsford, Sedgebrook	1·79	102	,, .	Oughtershaw Hall	4·46	...
,, .	Oundle	1·61	...	,, .	Wetherby, Ribston H.	2·45	126
Beds .	Woburn, Crawley Mill	1·65	96	,, .	Hull, Pearson Park	1·77	97
Cam .	Cambridge, Bot. Gdns.	1·55	106	,, .	Holme-on-Spalding	1·51	...
Essex .	Chelmsford, CountyLab	1·24	72	,, .	West Witton, Ivy Ho.	2·76	...
,, .	Lexden Hill House	1·40	...	,, .	Felixkirk, Mt. St. John	2·77	141
Suff .	Hawkedon Rectory	1·36	72	,, .	Pickering, Hungate	2·15	...
,, .	Haughley House	1·01	...	,, .	Scarborough	2·29	127
Norf .	Norwich, Eaton	1·37	72	,, .	Middlesbrough	2·82	180
,, .	Wells, Holkham Hall	...	...	,, .	Baldersdale, Hury Res.	2·18	...
,, .	Little Dunham	1·46	76	*Durh* .	Ushaw College	2·64	120
Wilts .	Devizes, Highclere	1·97	94	*Nor* .	Newcastle, Town Moor	1·77	84
,, .	Bishops Cannings	2·07	92	,, .	Bellingham, Highgreen	...	...
Dor .	Evershot, Melbury Ho.	2·29	77	,, .	Lilburn Tower Gdns.	2·97	...
,, .	Creech Grange	1·15	...	*Cumb* .	Geltsdale	2·18	...
,, .	Shaftesbury, Abbey Ho.	1·65	70	,, .	Carlisle, Scaleby Hall	2·65	108
Devon .	Plymouth, The Hoe	2·72	93	,, .	Borrowdale, Seathwaite	6·84	61
,, .	Polapit Tamar	2·82	95	,, .	Borrowdale, Rosthwaite	5·68	...
,, .	Ashburton, Druid Ho.	...	...	,, .	Keswick, High Hill	2·36	...
,, .	Cullompton	2·93	107	*Glam* .	Cardiff, Ely P. Stn.	2·49	77
,, .	Sidmouth, Sidmount	2·52	103	,, .	Treherbert, Tynywaun	4·51	...
,, .	Filleigh, Castle Hill	3·18	...	*Carm* .	Carmarthen Friary	3·23	85
,, .	Barnstaple N.Dev.Ath.	2·97	113	,, .	Llanwrda	3·84	83
Corn .	Redruth, Trewirgie	3·65	101	*Pemb* .	Haverfordwest, School	3·74	110
,, .	Penzance, Morrab Gdn.	3·69	115	*Card* .	Aberystwyth	2·51	...
,, .	St. Austell, Trevarna	4·22	123	,, .	Cardigan, County Sch.	3·20	...
Soms .	Chewton Mendip	2·59	72	*Brec* .	Crickhowell, Talymaes	3·80	...
,, .	Long Ashton	2·22	...	*Rad* .	BirmW.W.Tyrmynydd	3·75	70
,, .	Street, Millfield	1·72	...	*Mont* .	Lake Vyrnwy	4·83	113
Glos. .	Cirencester, Gwynfa	2·04	88	*Denb* .	Llangynhafal	4·36	...
Here .	Ross, Birchlea	2·77	136	*Mer* .	Dolgelly, Bryntirion	3·66	74
,, .	Ledbury, Underdown	2·61	137	*Carn* .	Llandudno	3·20	147
Salop .	Church Stretton	3·85	163	,, .	Snowdon, L. Llydaw 9	...	...
,, .	Shifnal, Hatton Grange	3·13	172	*Ang* .	Holyhead, Salt Island	3·73	142
Worc .	Ombersley, Holt Lock	2·15	127	,, .	Lligwy	2·86	...
,, .	Blockley	1·86	...	*Isle of Man*			
War .	Farnborough	2·45	116		Douglas, Boro' Cem.	3·02	102
,, .	Birminghm, Edgbaston	2·69	141	*Guernsey*			
Leics .	Thornton Reservoir	2·73	148		St. PeterP't.GrangeRd.	2·32	94

Rainfall: March, 1930: Scotland and Ireland

Co.	Station	In.	Per-cent of Av.	Co.	Station	In.	Per-cent. of Av.
Wigt .	Stoneykirk, Ardwell Ho	...	...	*Suth* .	Loch More, Achfary...	5·67	88
,, .	Pt. William, Monreith	2·28	...	*Caith* .	Wick.........	1·60	70
Kirk .	Carsphairn, Shiel......	4·92	...	*Ork* .	Pomona, Deerness......	1·74	62
,, .	Dumfries, Cargen......	3·22	89	*Shet* .	Lerwick	...	...
Dumf .	Eskdalemuir Obs.......	3·96	...	*Cork* .	Caheragh Rectory......	7·11	...
Roxb .	Branxholm	...	...	,, .	Dunmanway Rectory...	7·96	162
Selk .	Ettrick Manse.........	3·18	...	,, .	Ballinacurra.........	7·17	252
Peeb .	West Linton.........	2·22	...	,, .	Glanmire, Lota Lo......	7·18	232
Berk .	Marchmont House......	2·35	89	*Kerry* .	Valentia Obsy.........	6·54	144
Hadd .	North Berwick Res.....	1·78	95	,, .	Gearahameen.........	10·20	...
Midl .	Edinburgh, Roy. Obs.	2·15	120	,, .	Killarney Asylum......	...	...
Ayr .	Kilmarnock, Agric. C.	2·35	84	,, .	Darrynane Abbey.......	6·69	164
,, .	Girvan, Pinmore..	3·29	87	*Wat* .	Waterford, Brook Lo...	5·79	210
Renf .	Glasgow, Queen's Pk. .	2·56	98	*Tip* .	Nenagh, Cas. Lough...	5·01	162
,, .	Greenock, Prospect H.	4·40	90	,, .	Roscrea, Timoney Park	3·79	...
Bute .	Rothesay, Ardencraig.	3·26	91	,, .	Cashel, Ballinamona...	5·55	202
,, .	Dougarie Lodge.........	2·76	...	*Lim* .	Foynes, Coolnanes......	3·63	126
Arg .	Ardgour House	6·41	...	, .	Castleconnel Rec.......	4·89	...
,, .	Manse of Glenorchy...	5·70	...	*Clare* .	Inagh, Mount Callan...	5·34	...
,, .	Oban.........	3·84	...	,, .	Broadford, Hurdlest'n.	5·53	...
,, .	Poltalloch	3·07	80	*Wexf* .	Newtownbarry	...	...
,, .	Inveraray Castle...	5·06	80	,, .	Gorey, Courtown Ho...	5·30	230
,, .	Islay, Eallabus.........	3·65	95	*Kilk* .	Kilkenny Castle.........	3·96	173
,, .	Mull, Benmore.........	7·90	...	*Wic* .	Rathnew, Clonmannon	4·44	...
,, .	Tiree	...	...	*Carl* .	Hacketstown Rectory..	5·19	185
Kinr .	Loch Leven Sluice......	2·42	81	*Leix* .	Blandsfort House......	4·99	190
Perth .	Loch Dhu.........	6·05	92	,, .	Mountmellick.........	3·83	...
,, .	Balquhidder, Stronvar	4·64	...	*Off'ly* .	Birr Castle.........	3·74	156
,, .	Crieff, Strathearn Hyd.	2·24	70	*Dubl* .	Dublin, FitzWm. Sq...	3·19	165
,, .	Blair Castle Gardens...	1·30	50	,, .	Balbriggan, Ardgillan.	3·95	196
,, .	Dalnaspidal Lodge.....	...	...	*Me'th* .	Beauparc, St. Cloud...	3·61	...
Angus .	Kettins School.	1·87	85	,, .	Kells, Headfort.........	3·70	134
,, .	Dundee, E. Necropolis	1·64	80	*W.M* .	Moate, Coolatore......	3·80	...
,, .	Pearsie House.........	1·51	...	,, .	Mullingar, Belvedere..	3·82	141
,, .	Montrose, Sunnyside...	1·32	63	*Long* .	Castle Forbes Gdns......	4·21	143
Aber .	Braemar, Bank...	1·56	52	*Gal* .	Ballynahinch Castle...	5·44	106
,, .	Logie Coldstone Sch....	1·07	41	,, .	Galway, Grammar Sch.	3·06	...
,, .	Aberdeen, King's Coll.	1·33	55	*Mayo* .	Mallaranny.........	4·81	...
,, .	Fyvie Castle.........	2·30	...	,, .	Westport House.........	3·17	81
Moray .	Gordon Castle.........	1·26	54	,, .	Delphi Lodge.........	7·98	...
,, .	Grantown-on-Spey......	...	...	*Sligo* .	Markree Obsy.........	3·09	89
Nairn .	Nairn, Delnies	1·01	54	*Cav'n* .	Belturbet, Cloverhill...	2·76	100
Inv .	Kingussie, The Birches	1·24	...	*Ferm* .	Enniskillen, Portora...	2·88	...
,, .	Loch Quoich, Loan.....	8·51	...	*Arm* .	Armagh Obsy.........	2·14	91
,, .	Glenquoich.........	7·02	72	*Down* .	Fofanny Reservoir......	5·99	...
,, .	Inverness, Culduthel R.	1·26	...	,, .	Seaforde.........	2·91	100
,, .	Arisaig, Faire-na-Squir	3·78	...	,, .	Donaghadee, C. Stn...	1·65	75
,, .	Fort William.........	4·80	...	,, .	Banbridge, Milltown...	1·97	...
,, .	Skye, Dunvegan........	5·12	...	*Antr* .	Belfast, Cavehill Rd...	1·95	...
R & C .	Alness, Ardross Cas ...	1·95	60	,, .	Glenarm Castle.........	3·01	...
,, .	Ullapool	2·70	...	,, .	Ballymena, Harryville	2·72	86
,, .	Torridon, Bendamph...	6·56	87	*Lon* .	Londonderry, Creggan	3·15	98
,, .	Achnashellach.........	5·04	...	*Tyr* .	Donaghmore.........	2·41	...
,, .	Stornoway.........	3·07	75	,, .	Omagh, Edenfel.........	3·49	111
Suth .	Lairg.........	1·87	...	*Don* .	Malin Head.........	2·23	...
,, .	Tongue	3·48	104	,, .	Dunfanaghy.........	2·81	...
,, .	Melvich.........	3·05	...	,, .	Killybegs, Rockmount.	4·05	79

* For Indian stations a rain day is a day on which 0·1 in. or more rain has fallen.

Climatological Table for the British Empire, October, 1929.

STATIONS	PRESSURE		TEMPERATURE									PRECIPITATION			BRIGHT SUNSHINE	
	Mean of Day M.S.L.	Diff. from Normal	Absolute Max.	Absolute Min.	Mean Values Max.	Mean Values Min.	Mean Values ½ max. and min.	Mean Values Diff. from Normal	Mean Wet Bulb	Relative Humidity	Mean Cloud Am'nt	Am'nt	Diff. from Normal	Days	Hours per day	Percentage of possible
	mb.	mb.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	%	0—10	in.	in.			
London, Kew Obsy.	1010·5	− 3·5	64	31	56·7	43·2	49·9	0·0	45·3	92	6·3	2·73	+ 0·03	14	3.5	33
Gibraltar	1017·5	+ 0·3	80	51	73·7	60·3	67·0	+ 0·9	58·8	83	4·3	2·58	− 0·73	6	..	..
Malta	1016·4	− 0·2	80	58	73·2	63·2	68·2	− 2·7	61·5	70	4·1	1·11	− 1·76	7	8·4	74
St. Helena	1014·5	+ 2·1	..	53	..	53·6	..	..	54·5	97	9·8	1·66	− 0·25	22	..	..
Sierra Leone	1013·5	+ 1·9	89	69	85·2	71·9	78·5	− 1·6	75·8	85	4·6	10·69	− 1·93	21	..	..
Lagos, Nigeria	1009·0	− 2·7	89	70	85·6	73·8	79·7	+ 0·2	76·0	83	8·6	6·03	− 1·73	11	..	..
Kaduna, Nigeria	1014·8	+ 2·5	92	..	87·0	..	..	..	71·3	78	1·0	3·47	+ 1·29	11	..	..
Zomba, Nyasaland	1009·7	− 1·2	91	59	87·9	66·4	77·1	+ 3·0	..	52	2·8	0·49	− 1·03	3	..	..
Salisbury, Rhodesia	1008·1	− 0·5	90	52	85·5	60·3	72·9	+ 2·2	59·4	39	1·8	1·11	− 0·03	5	9·8	78
Cape Town	1019·2	+ 1·8	87	44	70·3	54·2	62·3	+ 1·1	55·7	70	4·2	0·58	− 1·07	6	..	..
Johannesburg	1013·0	− 0·2	82	50	74·5	55·5	65·0	+ 2·3	56·2	68	4·8	4·17	+ 1·61	15	8·5	67
Mauritius	1017·4	− 0·8	84	61	79·7	64·9	72·3	− 0·4	68·2	65	6·3	0·87	− 0·51	14	7·9	63
Bloemfontein	..	..	..	..	..	..	..	..	..	..	..	0·69	− 0·99	..	..	..
Calcutta, Alipore Obsy.	1009·7	+ 0·3	92	68	87·3	74·7	81·0	+ 0·3	75·9	89	3·5	11·51	+ 7·32	10*	..	..
Bombay	1009·9	+ 0·1	95	73	88·9	75·9	82·4	+ 0·1	75·6	83	3·2	4·82	+ 3·15	5*	..	..
Madras	1008·7	− 0·2	97	72	90·0	75·9	82·9	+ 0·6	76·5	83	6·1	6·69	− 5·03	8*	..	..
Colombo, Ceylon	1011·0	+ 0·7	87	71	85·5	74·5	80·0	− 0·3	76·8	75	6·8	4·74	− 8·38	19	8·0	67
Hongkong	1014·1	+ 0·5	86	69	80·6	73·2	76·9	0·0	69·9	66	3·7	0·14	− 4·71	4	9·3	80
Sandakan	..	..	90	72	87·7	74·5	81·1	− 0·4	77·5	84	..	15·01	+ 5·01	19	..	..
Sydney, N.S.W.	1015·7	+ 0·8	86	47	68·2	55·7	61·9	− 1·6	57·4	66	5·9	9·13	+ 5·92	14	6·9	55
Melbourne	..	..	83	42	66·4	50·3	58·3	+ 0·7	51·5	60	6·6	2·82	+ 0·23	15	5·1	39
Adelaide	1017·9	+ 1·9	92	43	71·7	50·7	61·2	− 0·7	53·3	51	6·6	1·03	− 0·71	10	8·3	64
Perth, W. Australia	1016·6	− 0·2	85	42	71·3	52·1	61·7	+ 0·7	54·6	57	5·6	1·09	− 1·09	9	8·2	64
Coolgardie	1015·2	0·0	94	39	78·7	50·1	64·4	+ 0·8	51·5	33	2·3	1·37	+ 0·63	3	..	..
Brisbane	1015·7	− 0·5	88	53	78·9	59·5	69·2	− 0·6	61·8	57	4·9	2·58	+ 0·01	10	8·4	66
Hobart, Tasmania	1013·7	+ 3·1	75	38	61·1	47·0	54·1	+ 0·1	48·7	66	8·0	1·48	− 0·78	17	5·1	39
Wellington, N.Z.	1018·7	+ 5·6	66	38	58·5	46·7	52·6	− 1·7	50·3	75	7·0	2·24	− 1·84	13	6·2	47
Suva, Fiji	1013·6	+ 0·4	84	65	81·6	71·0	76·3	+ 0·3	72·4	79	7·3	10·85	+ 3·05	13	5·2	42
Apia, Samoa	1010·8	− 0·7	88	71	84·7	74·3	79·5	+ 1·1	76·9	79	5·0	12·58	+ 6·52	19	6·6	53
Kingston, Jamaica	1011·4	− 0·1	90	69	86·8	72·4	79·6	− 0·9	71·6	88	4·9	4·96	− 2·50	11	6·7	57
Grenada, W.I.	1009·0	− 1·6	90	72	87·6	74·5	81·1	+ 1·0	74·9	71	4·1	9·49	+ 1·84	16	..	..
Toronto	1017·0	− 1·0	72	28	55·8	41·1	48·5	+ 1·6	42·1	74	7·2	2·29	− 0·17	8	4·0	36
Winnipeg	1018·3	+ 3·0	78	19	55·2	36·1	45·7	+ 4.9	37·3	96	5·0	0·90	− 0·53	6	4·7	44
St. John, N.B.	1014·9	− 1·6	65	25	52·7	40·1	46·4	+ 1·1	43·4	83	6·6	5·37	+ 0·83	12	4·1	37
Victoria, B.C.	1019·1	+ 1·5	67	41	58·8	47·7	53·3	+ 2·9	50·2	83	6·1	1·23	− 1·32	14	4·6	42

								+ 4·9	57·3	96	5·0	0·90	—	0·53	6	4·7	44
St. John, N.B.	1014·9	— 1·6	65	25	52·7	40·1	46·4	+ 1·1	43·4	83	6·6	5·37	+	0·83	12	4·1	37
Victoria, B.C.	1019·1	+ 1·5	67	41	58·8	47·7	53·3	+ 2·9	50·2	83	6·1	1·23	—	1·32	14	4·6	42